

NEUROSURGICAL CLINIC

UNIVERSITY OF ZURICH

Director: Prof. Dr. H. Krayenbühl

Acute Postoperative Urinary Bladder Retention

INAUGURAL-DISSERTATION

presented to the Faculty of Medicine
of the University of Zürich
in order to obtain the degree of
Doctor of Medicine

by

HAROLD GREGORY PLAKINS

of New York

Accepted on proposal of Prof. Dr. H. Krayenbühl

ZURICH - 1953



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TO
MY MOTHER
AND
MY WIFE
IN
GRATITUDE

ACUTE POST-OPERATIVE URINARY BLADDER RETENTION

INTRODUCTION

In the postoperative period following major surgery on many organs, and in particular those below the diaphragm, a complication is frequently to be observed which delays prompt recovery of the patient and adds much to his discomfort, namely his retention of urine. After such varied surgical operations as appendectomy, cholecystectomy, genitourinary tract surgery, operative deliveries, orthopedic operations, and surgery on various parts of the nervous system, the patient is very often unable to void spontaneously for days at a time. Surgeons have long labelled such conditions after the chief symptom present, "postoperative urinary bladder retention," but it is important to keep in mind that there is more than one reason for a patient's failure to pass urine spontaneously and promptly in the postoperative period. Frequently the trouble is not to be sought in the urinary bladder itself, but in some other segment of the excretory system, or in nervous control over this system.

Cutting (1) has given the following very workable classification scheme of the various causes of postoperative urinary retention:

Group I—Suppression or "Secretory Anuria." Here, the failure lies in the kidney itself. The cause has been variously attributed to: low blood pressure following loss of considerable quantities of blood during operations; body dehydration; blood concentration, and "idiopathic."

Group II—"Postrenal Anuria." In this condition, kidney function is intact, but the urinary passageways somewhere along the line from the pyelon to the fossa navicularis of the penis have been occluded. Such occlusion can have resulted from a multitude of factors: periureteral edema can have blocked the ureter following surgery in this area, the ureter itself may have been inadvertently ligated during gynecological surgery, or the ureteral lumen blocked by the passage of a kidney stone into it. Even when the ureteral passage remained patent, retention can follow abdominal hysterectomy where the base of the bladder is dissected free from its attachment to the uterus. Then, important motor and sensory pathways to the ureter and bladder are disrupted, and function of these organs thereby interfered with. Surgical procedures involving the male urethra, such as the various prostatesctomies, make physiological function of the urethra for a time difficult, since periurethral edema and bloody extravasations collect in and around the organ.

Group III—Functional Urinary Bladder Retention. Reference to this condition as a "true postoperative urinary *bladder* retention" is more in keeping with actual pathological-anatomical vesical findings. All parts of the urinary tract with the exception of the bladder, are anatomically and functionally intact. The kidney has secreted its product, the urinary excretory ducts have delivered the urine to the bladder, but this organ, owing to the hypotonic or atonic condition of its musculature, is quite unable to expel its contents. The result is the accumulation of a large amount of residual urine, an overstretching of the bladder, much as if this organ were simply an elastic bag. This state is fortunately in most instances of short duration, rarely lasting more than one week, usually less.

This paper will deal almost exclusively with the third type of postoperative urinary retention, Cutting's "functional retention." An attempt will be made to gain some insight into the probable etiology and pathogenesis of this so frequent postoperative complication. Original experimental data and statistical findings will be presented. On these considerations, the therapy of the condition will be discussed.

INCIDENCE OF ACUTE POSTOPERATIVE URINARY BLADDER RETENTION

There seems to be no uniformly accepted definition of the time interval which must have elapsed since operation before inability to void urine can correctly be labelled, "urinary retention." Obstetricians measure it in hours, other clinicians in days. For this paper, "urinary retention" was diagnosed if catheterization was found necessary because of the patient's inability to micturate spontaneously for more than *twenty-four hours* following the operation.

The following gives some idea of the frequency of this complication of the postsurgical period after various types of operations.

Jordon (2) estimates that some 50% to 80% of all patients undergoing surgery of all types develop urinary retention to some measurable degree in the postoperative period. Woodruff and Te Linde (3), investigating the condition on gynecological laparotomy cases, found that no less than 51% of a series of 257 patients were unable to urinate spontaneously for varying periods of time after the operation. The same authors were able to observe this complication in 58% of a group of 119 patients upon whom vaginal plastic operations had been performed. Failure to void urine spontaneously is a regular and hardly pathological condition in puerperium, not only after protracted operative deliveries, but also after apparently normal parturition. Thus Roll (4)

reports that he was obliged to catheterize 13.8% of a large series of women following normal deliveries. Gordon (5), in a series of 318 control cases among which figured hemorrhoidectomies, gynecological laparotomies, hernioplasties, appendectomies and cholecystectomies, observed that 27.6% of these patients developed retention in the postoperative period. A breakdown of this average figure is interesting for the conclusions which may be drawn thereupon: 23 of 80 hemorrhoidectomies (=28%), 14 of 46 gynecological laparotomies (=11%), and 5 of 40 cholecystectomies (=13%), were unable to micturate normally postoperatively. Gordon's comparison of the frequency of retention associated with a particular operation, reveals that the *type of operation* is a decided factor in influencing the frequency of the complication. Thus, the incidence in the hemorrhoidectomy-gynecological laparotomy group was significantly two-and-one-half to three times that of the hernioplasty-appendectomy-cholecystectomy group. The same author noted that the *type of anesthesia* and *type of anaesthetic* used also influenced the frequency of bladder atony, but in some not readily explainable manner. He found, for example, that the highest incidence of urinary retention was associated with the employment of an inhalation type of anaesthesia, while the lowest occurred when spinal anesthesia was the route used.

In the series of 173 laminectomy cases to be reported on presently in this paper, the incidence of postoperative urinary retention was 26.8%. It is important to recall that a typical laminectomy does not disturb the intactness of the contents of the abdominal cavity, as is the case with some of the operations mentioned above. Some causal mechanism other than that operative in the former cases must therefore be sought for laminectomized patients. Retention associated with a laminectomy is very likely of the functional type, along with that following appendectomy and cholecystectomy, and other operations not grossly disrupting the vascular-nervous supply of the bladder. It is to be differentiated from the symptomatologically similar complication following low abdominal operations. Parturition retention and that following gynecological laparotomy is very likely a combination, for the most part, of secretory and postrenal anuria.

MATERIAL

Material for this paper was gathered on patients who were undergoing a laminectomy for removal of a herniated intervertebral nucleus pulposus at the Neurosurgical University Clinic, Zurich, Switzerland,

during the years 1950, 1951, and 1952. The investigations were divided into three portions: a first series of 95 patients was observed pre-and-postoperatively exploratively for orientation on the problem. Next, 14 patients about to be laminectomized were cystometrographed *pre-operatively*, and the procedure repeated *postoperatively*. Lastly, seeking to improve on empiric routine therapy widely used, 61 such patients were administered a parasympathicomimetic drug, prostigmine, and the results on the frequency of postoperative urinary retention compared with a control group of 95, not receiving this drug.

In 1950, the first group consisting of 95 unselected patients was observed for the following data:

1. Age and sex of the patient.
2. Any disturbances of micturition clinically evident before the operation?
3. Level of the intervertebral disc lesion.
4. Quantity of anesthetic administered.
5. Length of time under anesthetic.
6. When in the postoperative period was patient first able to urinate spontaneously?

Of the 95 patients, 63 were male, 32 female. None of the patients had reported any difficulty in micturition upon their first coming to the clinic. All males were within 20 to 40 years of age, with the largest number, 22, within 30 to 40 years ($=29\%$). 81% of the females were between 20 and 50 years of age, 40 to 49 years being most common. ($=44\%$). In agreement with statistics usually given in the literature, the majority of the herniated discs occurred at the level between L4-L5; of the 95 cases, 63 were verified at operation to have occurred at this level (66.3%), while 26 of the remaining cases were between L-5-S1. Patients were anesthetized an average of 100 minutes, and the agent used in all cases was the same: nitrous oxide-ether. 225 ccm., on the average, of ether was administered using a semi-closed system and intratracheal intubation.

Analysis of this data reveals the following:

Firstly, of the 95 patients, 25 ($=26.3\%$) retained in the postoperative period. Of these 25 individuals, 13 were females, 12 were males. Thus, 13 of a total of 32 laminectomized females developed troubles of micturition postoperatively ($=41\%$), while such was the case with only 12 of a total of 63 males (19%). *The incidence of urinary bladder retention for females was hence more than twice as high as for males!* Although the number of cases upon which this ob-

servation was made was too few to be of real statistical significance, the tendency for females to retain more frequently than males is a fact which must not escape attention, and is related to other factors concerned in postoperative urinary retention to be elaborated upon more fully later on in this paper.

Secondly, although 44% of female patients retaining were aged from 40 to 49 years, only 18.8% of males were in this same category.

Thirdly, the average length of time patients were anesthetized was for both male and female patients *not* retaining postoperatively, 110 minutes, but for the retention cases, 90 minutes. Further, females retaining postoperatively were also anaesthetized shorter periods of time than their male counterparts.

Fourthly, when females were unable to micturate spontaneously postoperatively, it was for longer periods of time than males also developing the same complication. Thus, 13 females retaining did so for an average of 120 hours, while 12 males averaged 74 hours before being able to urinate spontaneously.

These observations lend support to the idea that urinary retention is especially apt to appear in persons, particularly females, with a special sensitive reaction to inhalation anesthetics.

SOME IMPORTANT ANATOMICAL, PHYSIOLOGICAL, AND NEURO-LOGICAL CONSIDERATIONS CONCERNING BLADDER FUNCTION

Before entering into a discussion of the role of various factors operative in postoperative urinary bladder retention, a short review of certain pertinent points with regard to the anatomy, neuro-anatomy, neuro-physiology, physiology and pathology of the bladder would seem indicated.

The human urinary bladder is a hollow viscus organ, of a shape varying according to its state of fullness. When empty and contracted, the bladder has been likened in its shape to the forepart of a ship, with four angles to each of which a duct is attached: the urachus to the anterior angle or apex, the right and left ureters to the postero-lateral angles, and the urethra to the most inferior angle or "neck." The bladder rests upon the rectum as if upon a shelf. When full, the bladder assumes the shape of a large wine goblet, being somewhat flattened on its superior aspect (6).

The non-striated musculature of the bladder can be differentiated into three layers: an external longitudinal, an inner reticular network, the fibers of which are for the most part also disposed in the long axis of the organ, and finally an important middle layer, composed of cir-

cularly distributed fibers. The three muscle layers of the bladder make up collectively what has been called since Elden (1722), the detrusor vesicae.

Muscular fibers of the middle, circular, layer converge at the most inferior portion of the bladder to form an incomplete ring-like structure, the internal sphincter. The external sphincter, unlike all muscle tissue so far described, is made up of striated muscle fibers, and is hence under voluntary control. This sphincter encircles the membranous portion of the male urethra, and is assisted in its portal closure function by a further voluntary muscle, the bulbocavernosus.

Physiologists place the urinary bladder in a unique category among the visceral organs, for here is an organ whose function is regulated chiefly by autonomic nerves, yet the act which it brings about, micturition, can be restrained or initiated at any point along the way through intervention of the will.

There are several levels of nervous control over vesical function, and an appreciation of this arrangement is essential in correlating a particular type of bladder dysfunction with a lesion at a particular level. As already alluded to, sensory organs are richly distributed among the connective tissue fibers and detrusor fibers of the bladder wall. The adequate stimulus of these nerve endings is tension. The stimulus is relayed up through the pelvic and hypogastric nerves to the posterior roots of the second, third, and fourth sacral nerves. Here the impulse enters the corresponding spinal segment, and the nervous pathway is continued on to cells in the anterior roots, where a new fiber, carrying efferent impulses for the bladder, is then formed. The fiber can then be traced to ganglion cells within the bladder wall after having passed through the pelvic nerves (*nervi erigentes*). The lowest and most peripheral of the centers for the coordination of bladder function lies, then, in the sacral cord.

From the sacral level, impulses are relayed up and down cerebrovesical pathways in the cord to and from higher centers in the brain. The exact localization of these spinal ascending and descending pathways has been the subject of considerable investigation, with widely differing points of view having been expressed. The topography of these tracts is not of unimportance for bladder function, because being so peripheral, they are easy prey to mechanical compression. Mosso and Pellacani, (1) two of the earliest workers on the subject, in the 1880's, located these cerebrovesical trunks in the posterior segment of the cord, while another investigator, Stewart (8), later found them to be situated in the dorsal part of the lateral columns of the cord. McClellan (9),

basing his reports on his clinical findings, located the pathways in the anterolateral columns of the cord, while still a different author, Creevy, (10), indicated that motor fibers intended for the bladder course nearby to the pyramidal tract, that is, in the dorsal half of the lateral column, close to the cord's surface. Sensory fibers, in his opinion, occupy pathways in the posterior columns. According to Barrington (11), who has done pioneer work in the field employing cat subjects, bladder controlling impulses are carried through pathways in the next neighborhood to the pyramidal tracts; fibers of these pathways undergo much crossing in the sacral segments of the cord before finally emerging in the pelvic nerves.

When speaking of "voluntary control over bladder," this implies cortical control and regulation, and centers for micturition have been actually experimentally located in the cortex, the midbrain, and hind-brain. All three centers can be referred to as the "suprasegmental" levels of bladder control. Beatty and Kerr (12) in 1936, reported that electrical stimulation applied to the premotor area of the frontal cortex effected a rise in intravesical pressure which was followed by micturition. The same stimulus applied to the anterior hypothalamic nuclei resulted in an increase in detrusor tone, while stimulating the posterior nuclei inhibited the muscle. Other authors, working on cats, were able to glean much information from which certain conclusions, with reservation, can be carried over to man. Thus Barrington (13) was able to show that crushing a small area of the hindbrain of the cat in the vicinity of the cerebellar peduncle, resulted in loss of the animal's ability to empty its bladder spontaneously. Destruction of a limited area in the midbrain abolished the desire to micturate. Langworthy, Kolb and Lewis (14), confirmed these conclusions in similar experiments on their cat subjects.

Langworthy (15) has supplied this classical description of the art of micturition, "Micturition is initiated by a contraction of the vesical muscle itself. It is only after this contraction is well under way that the vesical orifice opens and the sphincter relaxes. Neither can be opened voluntarily. The vesical orifice thus opens following voluntary contraction of the detrusor. It is possible to willfully close the external sphincter, which leads to subsidence of vesical contraction."

This view had remained essentially uncontested for years, but Mullner and Fleischner (16), in 1949, investigating the exact mechanisms of voluntary micturition and its inhibition through the will, used bladder fluoroscopy, coming thereby to totally differing yet interesting conclusions. These workers conclude that the initiation or inhibition

of micturition is effected entirely through *striated*, that is voluntary, muscle of the perineum (the pubococcygeus and deep transverse perineal muscles), the diaphragm, the abdominal wall, and not as has been long thought, through willfull innervation of *smooth*, involuntary muscle of the detrusor. These voluntary muscles are supplied with somatic innervation (pudic nerve). According to these authors, coordinated action of these muscles through the agency of the will, results in a downward pull on the internal sphincter, and only then, that is, secondarily, does the detrusor contract. Micturition is willfully inhibited by an upward pull on the base of the bladder, this closing off the internal sphincter.

The human bladder does not act normally after the fashion of an inert elastic bag expanding indefinitely with each increment of fluid. Instead, the detrusor adjusts its tone to the quantity of fluid present in the bladder. When a certain tension threshold value has been reached, the "stretch reflex" results. The impulse is carried up and down the cord pathways already described above, and the end result is a contraction of the detrusor. This, according to the classical conception, initiates micturition, because intracystic pressure rises to such a degree that the internal sphincter is literally "forced" open. Thereupon follows reflex opening of the external sphincter and the act of micturition. This is the *reflex* portion of this complex act, upon which the suprasegmental bladder segments exert their modifying and regulating influence. Denny-Brown and Robertson (17) described the role of these centers as follows: "Detrusor activity is inhibited, and the external sphincter and pelvic floor muscles are contracted. Removal of this restraint activity and relaxation of the external sphincter through cortical intervention, allows the lower centers to complete the act reflexly."

PATHOLOGY

Neurogenic and neurological bladder are names given to identical bladder conditions where the abnormal function is attributable to disease or injury of bladder nerve supply at any of the levels enumerated above. Cord bladder, on the other hand, is a different condition and is a situation where bladder dysfunction is due to changes only in the spinal cord.

Langworthy (18) has compiled a list of the following disease states in which neurogenic bladder is known to occur: cerebral vascular accidents, brain tumors, parkinsonism, epilepsy, encephalitis, asymptomatic neurosyphilis, syringomyelia, Friedreich's ataxia, myatonia atrophica, acute anterior poliomyelitis, transverse myelitis, meningomyelitis, disseminated sclerosis, spina bifida, *psychosomatic dysfunction*, tabes

dorsalis, syphilitic paraplegia, amyotrophic lateral sclerosis, subacute combined sclerosis, and tumor or injury to the spinal cord.

As this paper will attempt to establish, the urinary retention following many types of operations, in particular a laminectomy, is due to a transitory form of neurogenic bladder in psychically disposed, labile persons.

McClelland (19) has suggested the following four categories of bladder disturbances of a neurogenic nature:

1. *The Uninhibited Neurogenic Bladder.* This is the type of bladder dysfunction which develops after hemiplegia in the wake of cerebral accidents, or agenesis of the cortical, the hypothalamic, and the hind-brain centers for micturition control, or their destruction through disease processes during life; in such individuals, willfull inhibition or initiation of the micturition act either never has developed, or else it has been abolished through disease. The disturbance is due to lack of coordination through the normally present suprasegmental centers of bladder control.

2. *The Reflex Neurogenic Bladder.* Here pathways between suprasegmental centers and the spinal cord ABOVE the sacral cord are diseased. The result is also an elimination of the influence of the will over the micturition process, but the peripheral, that is the *sacral* cord micturition center maintains an automatic type of micturition. On reaching a certain threshold level of tension, the stretch reflex is automatically elicited, without any inhibition from higher centers. The function of such a bladder is adequate, if we are to judge from the minimal quantities of residual urine to be found in the bladder after detrusor contraction.

3. *The Autonomous Neurogenic Bladder.* This type of bladder dysfunction develops in association with damage to peripheral bladder center tissue in the sacral cord. The individual detrusor fibers are then left to "shift for themselves," so to speak, and the result is complete chaos for their expulsion function. There is no coordination of their action, and a large amount of residual urine dams up, very much in analogy to the situation in auricular fibrillation, where muscle fibers are also decompensated (20).

4. *The Atonic Neurogenic Bladder.* This conditions will arise when the posterior roots subserving vesical function suffer damage in any form. The stretch reflex is absent because the sensory portion of the reflex arc has been disrupted. The sensation of bladder distension, of pain when the bladder is maximally filled, is practically eliminated. The

desire to urinate has been lost. The paradigm of this pathological situation is the bladder of a tabetic; overstretching of the detrusor fibers results in their decompensation and large amounts of residual urine collect in a maximally distended organ.

A *fifth* category of bladder dysfunction can be distinguished in patients who have suffered sudden trauma or disease to their spinal cord or column. Here there is a period of "spinal shock" in which there is practical cessation of bladder activity; this condition can remain without change for days and sometimes months.

That *psychic factors* directly influence bladder function has been known since the earliest investigators, Mosso and Pellacanni, (21) first recorded bladder contractions with their cystograph. Straub, Ripley, and Wolf (22) in 1949 reported on disorders of vesical function in a group of soldiers and civilians with personality problems and emotional stress situations. They found that characteristic cystometrographic curves were associated with bladder disturbances traceable to these states of psychic imbalance, and that two distinct types of bladder function were constant: either the bladder showed a state of hyperfunction, with small bladder capacity, urinary frequency, and dysuria, or else in contrast, a bladder hypofunction was constatable with large bladder capacity and *urinary retention*. These authors found the first bladder type to be associated with emotional states of anxiety and resentment, while the second was prone to be present in individuals displaying reactions of being overwhelmed by impending danger, or hysterical reactions. Thus this, the *sixth* type of neurogenic bladder is attributed to *psychogenic* factors.

Symptomatologically at least, the urinary bladder atony and retention appearing in the postsurgical period of the laminectomized patient is a combination of the fourth, fifth, and sixth categories of neurogenic bladder, so that in all, the bladder of such patients might be appropriately labelled, "psychosomatic atonic shock bladder." For such patients have had a goodly portion of their vertebral column suddenly rongeured away through the laminectomy, and for periods sometimes exceeding a week there is little evidence of bladder function. Cystometrographic recordings show very little bladder activity, with a hypotonic to atonic detrusor. Further, such patients seem to have lost the sensation of bladder distension for varying periods of time, reporting relatively little discomfort even with a bladder filling approaching the maximum. Psychogenic factors aplenty can be found in the hospital situation, the anxiety over the probable success of the operation, family conditions, lack of accustomed privacy, etc.

MEASUREMENT OF BLADDER FUNCTION

Various methods have become available for visualizing the function of the urinary bladder, among which can be mentioned: cystoscopy, vesical radiography-fluoroscopy, and cystometrography. Here, the last named method alone will be dealt with.

Cystometrography was probably first performed by Mosso and Pellacanni (22), as long ago as 1882. Their excellent monograph on the subject, "Sur la fonction de la vessie," made a very accurate analysis of the waves recorded by means of the new instrument, and the interpretation given these waves at that time has remained essentially accepted. After the First Great War, the cystometrogaph was first used extensively for diagnosis of the various bladder dysfunctions associated with paraplegias in war veterans, and in 1927, Rose (23) in the United States, demonstrated a very practicable revolving drum type of cystometrograph. The instrument in numerous personal variations has since that time gained immensely in popularity, Lowsley, Simmons and Muschat, and perhaps most important of all, Munro, each introducing further improvements on the original. All of these instruments are essentially designed to measure detrusor tone when successive increments of fluid are introduced intravesically.

Cystometrograms for this paper were prepared using the Munro tidal drainage outfit (24), which is both cystometer and automatic bladder drainer, if necessary, combined in one instrument. In addition, the outfit has the prime advantage of being simple in design, cheap, and can easily be disassembled and assembled by hospital personnel, and autoclaved. A calibrated liter infusion flask contains the irrigating fluid, which can be very weak oxycyanate or boric acid solution. The flask is connected through a drip bulb and rubber tubing to a calibrated water manometer, and also to the patient's bladder by means of a urethral catheter. After measuring the residual urine, the procedure is to empty the bladder and to allow the irrigating fluid to drip into the bladder at a constant rate of about 100 drops per minute. The manometric fluctuations in centimeters of water and the quantity of fluid introduced intracystically are then recorded on a chart as ordinate and abscissa respectively. A pressure curve, a *cystometrogram* is the result. In addition to the pressure curve, the following data is also recorded, as recommended by Muschat (25):

1. *Initial Desire to Void.* That is, at what degree of bladder fullness? It has been established empirically that this sensation is normally reported at a bladder capacity of some 200 ccm. At 400 ccm.

in the normal subject, a strong desire to void is usually reported, and at 500 ccm, the stretch reflex is normally elicited.

2. *Maximal Voluntary Pressure.* The patient is instructed to force the contents of his bladder with maximal force out against the manometer. The resultant rise in intravesical pressure gives some idea of the efficiency of the accessory muscles of micturition—that is, the muscles of the anterior abdominal wall, the pelvic floor, and the diaphragm. Muschat gives the normal value as lying between 40 and 60 cm. of water.

The pressure curve of a normal cystometrogram shows a gradual rise with increasing bladder capacity until about 500 ccm. have been introduced into the bladder. At this point, the stretch reflex is elicited and the curve then registers a sharp rise from the horizontal, reflecting the systole of the detrusor and the beginning of micturition. All along the pressure curve, small fluctuations are distinguishable, and of these, two distinct types can be recognized:

1. *Respiratory Waves.* These are from one to five centimeters in amplitude and represent changes in intraabdominal pressure and hence intravesical pressure due to excursions of the diaphragm and contractions of anterior abdominal wall muscles during talking, coughing, normal respiration, etc. These waves are not to be confused with the more important:

2. *Reflex Contraction Waves.* Which are due to adjustments of the detrusor to increasing bladder content. These waves usually produce greater fluctuations of pressure than the former type, occur in unspaced intervals, and have the tendency to increase in amplitude toward the end of the cystometrogram, just before the stretch reflex.

The constancy of the data of cystometrographic recordings always excites wonder. The same type of curve essentially is to be found in original and repeat cystometrograms even though the recordings may have been made years apart. Muschat (26) comments: "This would indicate the existence of a constant characteristic physiologic rhythm in the normal function of the urinary bladder of every individual."

CYSTOMETROGRAPHIC STUDY OF LAMINECTOMIZED PATIENTS

In this next, the experimental portion of these investigations into the nature and cause of postoperative urinary bladder retention, 14 patients, who were to be laminectomized for removal of a herniated intervertebral disc, were cystometrographed *PRE* and *POST* operatively. The goal was an analysis of the part played by the operation itself, the

anesthesia, etc. in bringing about the post operative retention complication.

Of the 14 patients, 12 were males, 2 were females. All had shown some or all of the typical symptoms associated with ruptured intervertebral disc: subjectively, the intense low back pain, spontaneous pain on coughing or sneezing, etc.; objectively: tenderness over lumbar and sacral spines, limited lateral flexibility of the spine, compensatory scoliosis, positive Kernig's and Lasegue's sign, patchy or faulty sensation along the fibular aspect of the leg, absent ankle jerks, muscular atrophy, and sometimes typical lumbar puncture findings. There was however no objective or subjective sign of pathological lesions of sacral nerve roots 2-5, unilateral or bilateral. Moreover, careful questioning of each patient before the operation and before the cystometrogram never brought to light any subjective or objective sign of urinary tract malfunction. The patients were for all intents and purposes, bladder healthy. They were seen shortly after their arrival in the clinic, usually within 24 to 48 hours before the laminectomy, and were cystometrographed before the customary diagnostic lumbar puncture. The Munro outfit was employed.

Of the 14 PREoperative cystometrograms, 4 were "classical," in that the curves fitted well the description of a normal cystometrogram of a bladder healthy person. Here could be made out the initial rise, then the plateau area, until about 500 ccm, had been introduced into the bladder, and then the sharp sudden rise, due to the stretch reflex and the unimpaired systole of the detrusor. Residual urine could not be collected from these bladders preoperatively, and the maximal voluntary pressure values were within the norm.

More impressive however, was the PREoperative cystometrographic recording of the bladder of the remaining 10 patients of the series. Here, with clinically bladder-healthy individuals, and satisfactory vesical function, two pathological function types could be discerned: (1): hyperfunction bladder: small capacity, quick rise in intracystic pressure even after minimal filling, premature stretch reflex elicitation, great excursions in amplitude of the reflex contraction waves, a decided shift to the left of normal of point of sensation of desire to void, and (2): hypofunction bladder: large bladder capacity, practically no rise in intracystic pressure despite bladder capacity of more than 650 ccm, late or absent stretch reflex, practically absent reflex contraction waves. The initial urge to void showed a tendency to shift towards the right of normal. The hypofunction bladder type far outnumbered the hyperfunction type, the ratio of incidence being 9:1 respectively.

These cystometrographic recordings reveal an altered bladder function over the normal even *before* any of the contemplated therapeutic procedures had been carried out. Interesting is a comparison of the results obtained with these PRE-operative cystometrograms and the bladder function types also recorded by the same method by the authors mentioned previously (Straub, Ripley and Wolf (27)). It is to be recalled that these authors were able to correlate certain emotional states with hypofunctioning or hyperfunctioning bladders. In analogy to the conclusions made by these contributors, it is therefore possible that the psychic stress, the hospital situation, the insecurity, etc., experienced by the preoperative laminectomy patient act to produce "variations in neural activity." It is this factor of emotional imbalance which probably represents the dispositional moment to untoward reactions with the ether anesthetic, and paves the way to postoperative urinary bladder retention. As will be shown immediately following, only such patients retained urine postoperatively whose bladders registered hypotonic to atonic pressures in the PREOPERATIVE cystometrogram. Although these patients were not examined psychiatrically previous to the laminectomy, as was the case with Straub, et al. before and during cystometrography, the existence of a common factor for the bladder conditions found during both investigations can be assumed. Absolute proof of a connection between psychic stress and bladder dysfunction is obtainable only through active cooperation among psychiatrist, neurosurgeon, and urologist, and is beyond the scope of this paper.

Forty-eight hours after the laminectomy, the cystometrogram was repeated on the same 14 patients and the results obtained compared for significant changes over the original, preoperative cystometrographic study.

No residual urine could be collected from the bladders of the 4 patients with "classical" preoperative cystometrograms, nor any from the one person with hyperfunctioning preoperative bladder. The shape of the curve remained essentially unchanged as compared with the original for these 5 persons. All Muschat criteria values were normal. None of these patients retained urine postoperatively.

Of the group of 9 patients with hypotonic to atonic bladders preoperatively, three developed acute postoperative retention; two were unable to urinate spontaneously for 72 hours following the laminectomy, while one patient retained for 192 hours after leaving the operating room! All three had not manifested a single sign of bladder dysfunction preoperatively, excepting what had been cystometrographically recorded! The shape of the repeat recording was not significantly different than

the preoperative cystometrogram, intracystic pressure showing no tendency to rise with increasing bladder content, now and then. The reflex contraction waves, noticeably small in amplitude in the original recording, had all but disappeared in the repeat curve. Maximal voluntary pressure values, pre-and-postoperatively were still within normal, so that faulty bladder function could not be attributable to lack of control over accessory muscles of micturition. The point of initial desire to void also showed no change over the original value, but the amount of residual urine recovered from the three patients showed a definite tendency towards increase: in one patient, the residual urine was total, in the other two, the cystometrographic recording was made when bladder function had begun to normalize itself. In the case of these two with partial return of normal bladder function, more than 100 ccm, of residual urine was collected.

Interesting also is the comparison of the quantity of anesthetic administered and the time interval anesthetized, with respect to the acute postoperative retention cases and those urinating normally in this period. In the first series of 95 patients described above, it was found that acute postoperative retention was most likely to complicate the recovery of patients who had been administered larger quantities of anesthetic for shorter periods than those not retaining urine. Here in the case of these three retention patients, the identical tendency could be observed: retention cases were given an average of 90 ccm. more of the ether than those without disturbances of micturition. Furthermore, the former group spent an average of 25 minutes less under the anesthetic than the latter group.

In summary, it is possible to divide the 14 patients of this series into three groups on the basis of their pre-and-postoperative cystometrographic recording:

1. A group of 4 patients with no difficulties of micturition in the pre-and-postoperative periods. Original and repeat cystometrograms show "classical," that is: *normal* values.

2. A group of 3 patients with no difficulties of micturition *before* operation, retaining urine for varying lengths of time *after* operation. Original and repeat cystometrograms record a hypotonic to atonic bladder muscle.

3. A group of 7 patients with normal micturition both before and after laminectomy. Pre-and-postoperative cystometrograms show one or other of two pathological function states: hyperfunctioning bladder (1 case), or hypotonic-atonic bladder (6 cases).

ETIOLOGY AND PATHOGENESIS OF ACUTE POSTOPERATIVE URINARY BLADDER RETENTION

Numerous theories have been proposed in an attempt to explain the nature and cause of acute postoperative urinary bladder retention. As is so often the case when so many explanations are offered, there is some essence of truth in all. Some of the etiological mechanisms mentioned here have little or no relationship to the type of retention following a laminectomy. Thus disorders of micturition complicating vaginal plastic operations, for example, are easily explainable as being due to congestive edema surrounding the bladder sphincters following surgery in the area. Abdominal hysterectomies disturb the normal innervation pattern of the bladder when the uterus is dissected out of its bed among the other pelvic organs. Passage of the infant's head during parturition compresses the urethra for varying periods of time, sometimes for hours if the delivery is protracted. Malfunction of these parts for some time following birth is then quite understandable.

Less easy to find an explanation for is the acute retention following hernioplasties, appendectomies and cholecystectomies. Here the pelvic anatomy has not been disturbed as was the case with the previous types of operations. Psychogenic factors are therefore thought to play some role in causing the retention here. On the basis of information gathered on laminectomy patients through pre-and-postoperative cystometry, where it was shown that emotional imbalance may bring about neural disturbances which then cause bladder dysfunction, this idea is not entirely without foundation. Although the entire explanation for the phenomenon cannot be found in such factors as the following, their connection with urinary retention is obvious, even to the layman: hospital environment of the patient; urination in the unaccustomed sitting-in-bed position; lack of privacy while urinating. There are however other mechanisms operative: (1): psychic and emotional imbalance of particular patients about to undergo a major surgical operation, and (2): an individual increased sensitiveness to anesthetic action during this period of emotional instability. These two factors in varying proportions very likely account for the greater incidence of the complication among female patients, especially those approaching the climacterium. Pharmacologists have long been cognizant of the fact that the female organism reacts to most drugs more often with untoward reactions than the male, and with smaller doses.

Topographically considered and making use of the McClelland classification discussed above, an attempt can be made to place the

factors operative in bringing about the neurogenic bladder associated with disc hernias into two categories:

(1): factors operative peripherally, that is: in the area of the laminectomy.

(2): factors operative centrally, that is: in the region of the suprasegmental centers for the control of bladder function in the brain.

It has been considered that retention might be due to mechanical interference with nervous pathways subserving micturition which course in the spinal nerves. It must be recalled, however, that the majority of disc hernias are found at the level of vertebrae L4-L5 (about 60%), while 30% occur between L5-S1, and S1-S2. Spinal segments carrying impulses concerning micturition are in S2, S3, and S4, as has been elaborated more fully already in opening remarks concerning bladder neuroanatomy. Furthermore, disc hernias are usually unilateral, and pressure on a single nerve root can hardly be considered of such moment as to interfere with bladder function seriously. Comparison and correlation of the incidence of postoperative urinary bladder retention with the level of intervertebral disc herniation, lends even less support to the argument for mechanical compression of spinal roots causing bladder dysfunction. Retention has been found much less frequently associated with the disc lesion at the L5-S1 (16% of such cases) than when the disc has been ruptured between L4-L5 (32.0% retentions), despite being further from bladder control centers than L5-S1.) It has however been thought conceivable that the postoperative edema collecting about the laminectomy area might compress sacral nerve roots mechanically, or at least interfere with physiological function of these nervous trunkways. This argument is considerably weakened by the fact that "saddle-anesthesia," such as might conceivably arise through interference with S2-S3 and S4 by postoperative edema, was not found in a single instance in patients with postoperative bladder atony of this series.

More promising is a consideration of a "central" origin of the bladder atony, in the sense that the bladder hypofunction already present in an emotionally labile patient is augmented by postoperative-post-anesthetic depression of bladder centers in the cortex, the midbrain and the hindbrain by the anesthetic administered during the laminectomy. In this connection, the observations of Gordon (28) concerning the relative frequency of postoperative urinary bladder retention after inhalation anesthesia and spinal-local anesthesia can be recalled. Retention was most frequent when general inhalation anesthesia had been used, and most infrequent where spinal-local anesthesia had been em-

ployed. A general inhalation anesthetic has a central depressing action on bladder control centers in the brain, and absorbed in the blood stream soon reaches peripheral bladder centers and nerves, and paralyzes them as well.

In summary, it can be said that individuals with psychogenic depression of bladder function before operation are the most likely candidates for acute urinary bladder retention in the postsurgical period. The already hypotonic or atonic bladder is further paralyzed through the action of inhalation anesthetics administered during the operation. Females, especially those approaching or already having entered climacterium, are twice as readily affected as male patients, and in much less time exposure to the anesthetic.

THErapy OF POSTOPERATIVE URINARY BLADDER RETENTION

Because urinary bladder retention so frequently and regularly complicates the postsurgical period of so different types of operations, surgeons of all specialties have long sought some means of reducing the incidence of the condition or at least reducing its severity when it does arise. Since the etiology and pathogenesis of the bladder atony is still in the "many theories" stage, no causal therapy can really be attempted but only symptomatic measures undertaken. Causal therapy would be, for example, that which would seek to counteract the fears, the insecurity and anxiety of the patient before his operation, as well as to reduce the quantity of anesthetic agent and central depressives administered during the operation. Causal therapy has for the most part made room for the more convenient symptomatic type.

Most frequently, surgeons in the past have followed the way of least resistance and have catheterized their patients when retention had set in. Catheterization is not the harmless procedure it would seem to be. Cystitis and cysto-pyelitis can result from the practice of repeated catheterization. Buddington and Graves (29) investigated the factors responsible for cystitis appearing after repeated catheterization in a large group of patients who had undergone all types of surgery. Such persons "on catheter drainage of the conventional type in the average hospital, acquire infection at least to the bladder level after from 2 to 6 days of catheterization. Such cystitides develop despite simultaneous and energetic administration of antibiotics and chemotherapeutics."

In an attempt to bypass the complications associated with frequent catheterization, several types of drugs have been developed for prophylactic and therapeutic use against acute postoperative urinary bladder retention. These have been variously successful. Everett (30) reports

a method introduced by Craig in 1925 at the Gynecological Service of the Johns Hopkins Hospital, Baltimore. 30 ccm. of a 0.5% aqueous solution of mercurochrome are instilled preoperatively into the bladder, and simultaneously, one liter of 2% sodium bicarbonate containing 60 ccm. of liquid petrolatum are introduced rectally. With this procedure it was reasoned that the bladder mucosa, chemically irritated by the mercurochrome, tended to increase bladder tone by stimulating detrusor contractions, this furthering spontaneous micturition in the postoperative period. The rectal instillations were supposed to bring about more efficient renal secretion and hence better bladder filling, this indirectly bettering detrusor tone. Woodruff and Te Linde (31) in 1939 reported on the incidence of postoperative urinary retention after use of this prophylactic procedure just outlined, and found that in the case of 500 patients who had undergone pelvic laparotomy only 6.5% subsequently required catheterization in the postsurgical period, as compared to 51% of a control series of 257 laparotomy patients who had not received this preoperative prophylactic treatment.

Other clinicians have sought practical application for the data which has been accumulating in recent years as the result of thorough investigation into the pharmacodynamics of the vegetative nervous system and its special role in urinary bladder control. Since the path-finding work of Langley, it has been the practice to think of the "autonomic nervous system" as consisting of two chief portions, the sympathetic and parasympathetic. It is now generally accepted that stimulation of parasympathetic nerves is followed by the deposition of acetylcholine at nerve-receptor junction. Acetylcholine is thought to act as a kind of "carrier" for the passage of the nervous energy from the stimulated nerve to the tissue to be stimulated. An enzyme, choline-esterase, has been demonstrated to be simultaneously in constant formation at the junction, and this substance, acting on its substrate acetylcholine, breaks the latter down to choline, which is only one-thousandth as effective a stimulant as the original. Some investigators have seen the cause of the bladder dysfunction following surgical interventions to lie in an imbalance in the components of the acetylcholine-choline-esterase system, perhaps in that too little acetylcholine is released, or too quickly broken down, or else too much choline-esterase formed. The problem confronting investigators into the pharmacodynamics of bladder dysfunction is essentially this: a principle must be developed which would either inhibit the choline-esterase or else further the formation of acetylcholine.

Marden and Williamson (32) have proposed the theory that

parasympathetic depression or sympathetic overstimulation is the rule in the postoperative patient. They have administered a cholinergic drug, prostigmine, prophylactically and therapeutically, and have reported excellent results in the reduction of the incidence and severity of postoperative acute urinary bladder retention. The same drug has for years been used with great success in the treatment of postoperative ileus, and the mechanism of this condition has been thought to be analogous to urinary bladder dysfunction in the postsurgical period.

Similar reasoning has resulted in the development of such parasympathicomimetic drugs as doryl, neostigmine, urecholine, and others.

Doryl, a synthetic preparation, has been used extensively for years in the treatment of acute postoperative urinary bladder retention and intestinal distension. Chemically, it can be described as the carbamic acid-choline ester chloride, and is a very effective stimulant of all parts of the parasympathetic nervous system. It is reputed to be one hundred times as effective a stimulant of the parasympathetic system as the natural product, acetylcholine, but has potentially dangerous side effects, so that caution where internal conditions are co-existent is advisable.

Starr and Ferguson (33) in 1940, were among the first to suggest the use of urecholine, a urethane of beta methyl choline chloride for cases of acute postsurgical urinary retention. Winter (34), in 1941, cystometrographed dog subjects, and established that urecholine increased bladder irritability and decreased bladder capacity by furthering detrusor tone. Since this earlier experimental work, considerable literature on the clinical application of this drug has accumulated. Adler (35) reports that he saw definite betterment in 44% of 55 postoperative retention cases after use of urecholine. The same author found urecholine to be effective after neostigmine had failed to relieve the condition in 2 cases, but on the other hand, the drug was not effective in 2 cases where neostigmine and furmethide were. Garvey, Bowman, and Ashbrook (37) tested the same drug on 76 patients who had just undergone various major surgical operations and were able to report spontaneous micturition, not to be distinguished from the normal, mostly within minutes after its administration.

It has long been known that physostigmine can be useful in the treatment of postoperative intestinal atony, but because of the unpredictable and severe nature of its side reactions, this drug has never found wide use in this connection. Interest in the pharmacodynamics of this drug has however led to synthesis of a different drug, prostigmine. Prostigmine has been found to be considerably freer of these undesirable side reactions, and is now routinely employed for the relief of intestinal

atony after abdominal surgery. Prostigmine has also been employed to good advantage for the relief of acute postoperative urinary bladder retention, however with much less convincing results than for the intestinal conditions. Marden and Williamson, two authors mentioned above, have published the results of their clinical application of prostigmine for such indications. Szubinski (38) in 1932, Bross and Kubikinski (39) in 1933, and Duschl (40) in the same year, were among the first to report good results following administration of the drug when postoperative urinary bladder retention had already developed. Szubinski gave prostigmine therapeutically to 18 surgical patients, mostly herniotomies and appendectomies, after they were unable to void urine spontaneously in the postoperative period. He observed prompt normal micturition to follow subcutaneous administration of prostigmine in 30 to 90 minutes. Bladder retention never reappeared subsequently in any of the cases treated in this fashion. Bross and Kubikinski (41) confirmed the results of the previous author, and administered prostigmine routinely subcutaneously for postoperative urinary retentions, reserving intravenous administration for particularly protracted retentions. Seven retentions were reported to have developed following herniotomy, appendectomy, and one operation for duodenal ulcer, and prostigmine relieved the complications in all cases. The same authors demonstrated protracted tetanic muscular contractions when prostigmine was added to fluid in which were dipped isolated guinea pig and rabbit bladder preparations. These reactions were still to be observed when the drug was diulted down to one part in four hundred thousand!

Because prostigmine was reported as being very effective in the treatment of postsurgical urinary bladder retention following such various types of operations, it was decided to test the effectiveness of the drug against the retention so frequently complicating a laminectomy.

During 1952, 61 unselected patients suffering from intervertebral disc herniation, were observed before and after the laminectomy. Special attention was paid to any sign of bladder dysfunction. None of the patients complained of any bladder trouble before operation, after close questioning, and all were in good health excepting for the symptoms directly attributable to their herniated disc. 26 were females, 35 were males. The prophylactic prostigmine plan suggested by Marden and Williamson and already referred to above, was used in all 61 cases. Briefly, prostigmine was given as follows: **PREOPERATIVELY:** 1 ampule intramuscularly every four hours, a total of four ampules in the presurgical period. **DAY OF OPERATION:** 1 ampule intramuscularly

on arising, and on leaving the ward for the surgery, an additional ampule. POSTOPERATIVELY: immediately following laminectomy, 1 ampule, additional ampules every four hours until the patient was able to micturate spontaneously.

The results obtained employing this drug prophylactically are interesting but disappointing. In summary, it can be said that the convincing benefits reported following its use after other types of surgery cannot be confirmed for the laminectomy. Despite this energetic and consequent program of protigmine administration, *no significant change* in the incidence of postoperative urinary bladder retention over the control series of 95 patients followed in 1950 who were not treated in this manner, could be observed. Both patient series had been subjected to identical operative procedures, at the identical clinic, in most instances by identical operators. Where 25 of the 95 control cases (=26.3%) were unable to urinate spontaneously for more than 24 hours following the laminectomy, 17 of 61 protigmine treated patients (=27.9%) developed the same complication postsurgically. The same tendency of females to retain more frequently than males postoperatively, already observed in the control series of 1950, could be made out in this new protigmine treated series.

SUMMARY

The incidence, pathogenesis, etiology, and therapy of acute urinary bladder retention as it complicates the postoperative period following laminectomy, was studied on the basis of a total of 173 cases of herniated intervertebral disc subjects. Of this number, a first series of 95 patients was carefully observed for any symptoms or signs relating to clinically evident bladder dysfunction before the operation, and none were found. Further, the age and sex of the patient, the quantity of anesthetic administered and the length of time anesthetized during the laminectomy was also noted, and particular attention paid to the time interval elapsing before the patient was able to urinate spontaneously in the postoperative period.

It was found that some 26% of such patients retained urine for more than 24 hours postoperatively, and that of this number, the incidence among the female subjects was twice as high as among similar male subjects. Further, it became evident that some relationship must exist between the length of time such persons, particularly females, were anesthetized and the incidence of urinary bladder retention in the post-

surgical period, because retention cases were found to spend an average of 20 minutes less under the anesthesia than those micturating normally subsequent to the laminectomy. When females did develop the complication, they were apt to retain urine for longer periods than males. Finally, such females retaining urine were likely to be in an older age group than similar male patients also retaining.

All these factors can be construed as pointing to the inhalation anesthetic as at least one important etiologic moment in the causation of postoperative urinary bladder retention.

In a next series of 14 patients, a cystometrogram employing the Munro tidal drainage outfit was performed pre-and-postoperatively. These recordings give some concrete evidence of the meaning of "predisposition" to untoward reactions to the anesthesia and anesthetic. The predisposition is the result of the emotional instability of certain individuals during the presurgical period. According to this hypothesis, this psychic imbalance leads to a depression of bladder activity over cortical centers of bladder control, resulting in an atonic to hypotonic bladder. 10 of these 14 patients cystometrographed preoperatively had curves of a type usually found in bladder pressure tracings of tabetics, or spinal shock patients, or as was significantly shown by Straub, Ripley, and Wolf, of *emotionally unstable persons in a stress situation*. Thus, 9 preoperative cystometrograms showed a hypotonic to atonic bladder in individuals who outwardly had absolutely no sign of clinical bladder dysfunction. There could be demonstrated on these persons before the laminectomy, a bladder with abnormally large capacity, a cystometrographic curve with no significant rise in intracystic pressure despite bladder fillings of more than 650 ccm., late or absent "stretch reflexes," practically absent reflex contraction waves, a decided shift to the right of normal for initial desire to void. 1 preoperative cystometrogram showed a hyperfunctioning organ. No change of importance could be seen in the shape of the postoperative cystometrogram or in any of the other data as compared with the preoperative recordings. 3 of these patients developed acute urinary bladder retention subsequent to the laminectomy. In all cases, it was found that retention was associated with hypo-to-atonic cystometrographic tracings pre-and-postoperatively. No retention without previous hypofunctioning bladder. This depression of bladder function already existing before the operation is then further aggravated by a postoperative-postanesthetic depression of bladder centers in the cortex, midbrain, and hindbrain.

In an attempt to develop some basis for a therapy to improve on the usual empiricism practiced in treating postoperative urinary reten-

tion, it was decided to give prostigmine prophylactically to 61 persons about to be laminectomized. For this drug and other parasympathicomimetics, it has been claimed that they stimulate the production of acetylcholine or else slow up its breakdown by cholineesterase and hence act to better parasympathetic function of sluggish organs. For these laminectomy patients, however, no significant change in the incidence of postoperative urinary retention was seen after prophylactic use of the drug; there was as much retention in 61 persons so treated as in 95 patients also laminectomized not receiving the treatment.

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CURRICULUM VITAE

Born in New York, N. Y., U.S.A. on Sept. 15, 1920. Attended the grammar and high schools there and in New Jersey, and from 1938 to 1942, attended Queens College, Flushing, New York. Graduated with degree of Bachelor of Arts.

1942 to 1946, service with the United States Army.

1947, began medical studies at the Faculty of Medicine of the University of Zurich, Switzerland, and in 1952, was graduated from this institution after having absolved the Federal Examinations for Foreigners.

